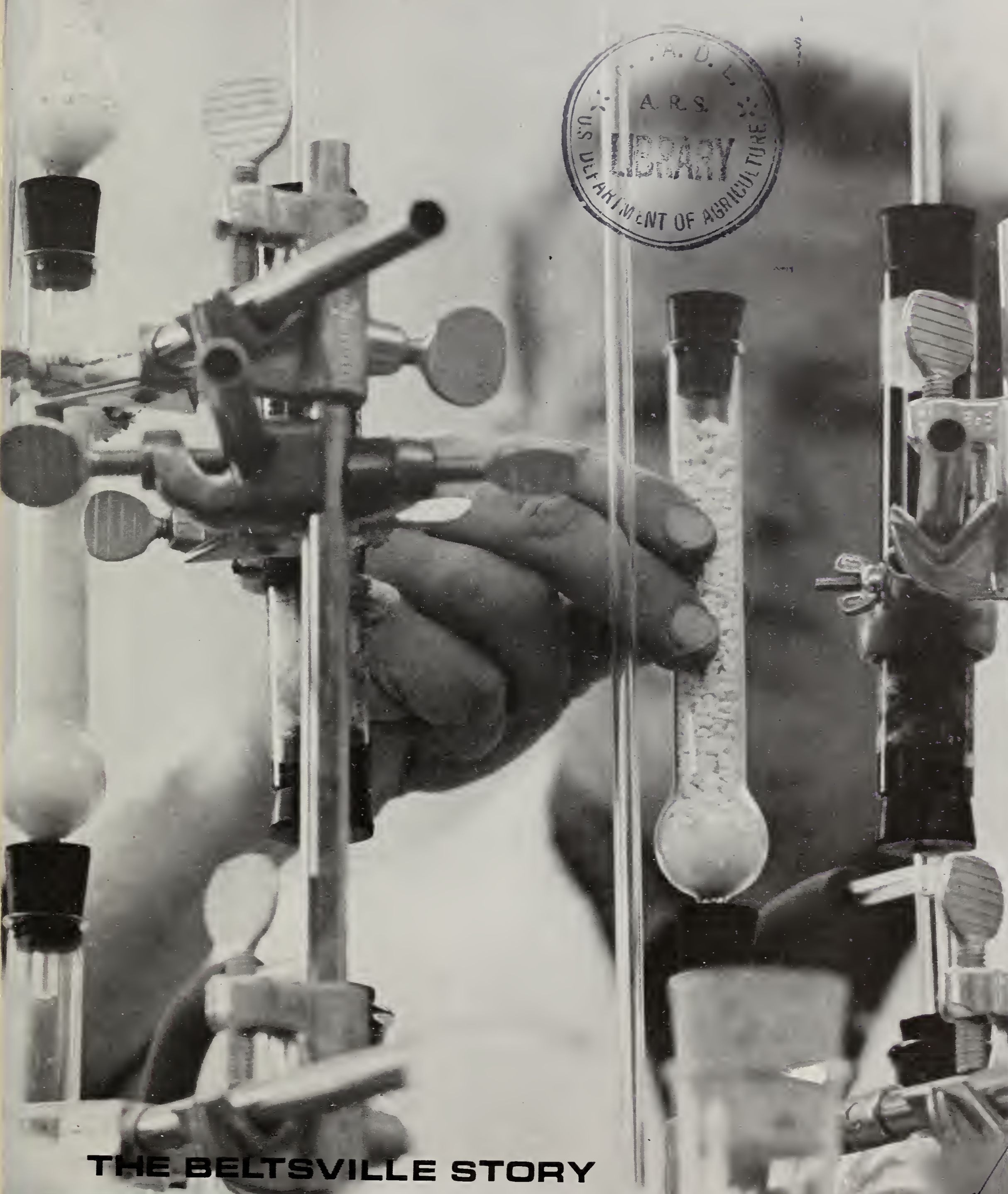
AGRICULTURAL
Research

OCTOBER 1963

U.S. DEPARTMENT OF AGRICULTURE



THE BELTSVILLE STORY

AGRICULTURAL
Research

OCTOBER 1963/VOL. 12, NO. 4

A Nation's Vigor

A nation's vigor is dependent upon the health of its agriculture.

This explains why hundreds of officials and heads of state visit Beltsville each year. They come because of the tremendous impact research has had on U.S. agriculture and on the vigor of this nation. Their visits—from 112 nations last year—point up this fact:

The most important help we can give our neighbors around the World may well be to share the technology gained through agricultural research that has made us the agricultural leader of the world.

Research has given us machines to fit our crops and, in some cases, crops to fit our machines. It has given us superior crop varieties and breeds of livestock. It has given us chemical and biological weapons to control many of the diseases and pests that threaten our farms and forests. It has given us more effective ways to protect our natural resources . . . new concepts of nutrition and adequate diets . . . and the means of getting fresh food to people the year around at reasonable prices.

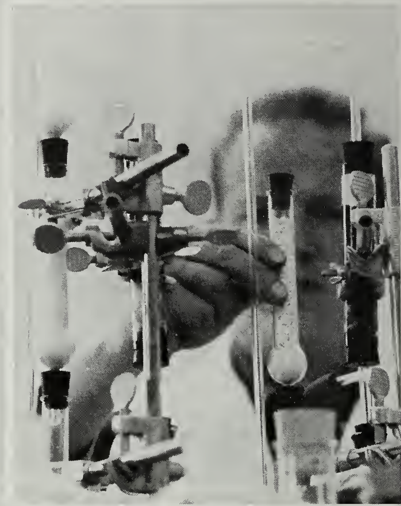
Only a century ago, during Abraham Lincoln's time, 60 of every 100 U.S. workers were needed to run this Nation's farms. Today, only 8 out of 100 do the job. And food in the United States is varied, plentiful, and healthful.

In achieving these successes, we have also assumed greater responsibilities for helping others who for many reasons have not been so fortunate. Nine out of ten workers in many developing lands devote their energies to farming, yet millions are underfed.

Emerging and developing nations can move ahead more rapidly as we help them produce the tools and techniques to solve problems in farm management, in the use of soil and water, and in the production of crops and livestock. In sharing our knowledge, we are doing essentially what other nations did two centuries ago for the new land that was to become the United States.

We are thus bolstering agriculture—and freedom—throughout the World.

THE COVER—Agricultural research at Beltsville includes a myriad of investigations. Here the breakdown of pesticides in soil is under study.



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Orville L. Freeman, Secretary,
U.S. Department of Agriculture

B. T. Shaw, Administrator,
Agricultural Research Service

A center of

WORLD LEADERSHIP

in agricultural research

By B. T. SHAW

Administrator, ARS

■ In Maryland, near the town of Beltsville, the Research Center of the U.S. Department of Agriculture covers 11,000 acres. On this land, 1,200 scientists are working on 3,000 research projects. They use 3,000 head of experimental cattle, hogs, sheep, and goats; 10,000 chickens and turkeys; and 1,160 buildings, including laboratories, offices, and shelters for livestock and machinery.

But more important than its size is Beltsville's role of leadership in agricultural science. Scientists at the Research Center have helped set the pace for technological revolution in American agriculture, and they have made friends for U.S. farm research around the world.

Beltsville's leading position in world agriculture is a symbol of this Nation's energetic search for knowledge—knowledge that enables the American farmer to have a more profitable and satisfying life; that results in an abundance of healthful food for American people; that benefits the agriculture of all nations; and that helps solve problems in fields of science other than agriculture.

A cooperative relationship

In contributing to this knowledge, Beltsville scientists have worked closely with scientists in State agricultural experiment stations and in industry. The cooperative relationship began on a nationwide scale a century ago, when Congress established the Department of Agriculture and the State land-grant colleges. Later legislation established the State experiment stations and provided them with Federal-grant funds.

Beltsville, which is the hub of USDA research, directs most of its efforts toward problems of regional or national significance. Frequently, it teams up with one or more State experiment stations to work on a particular problem.

Such a partnership approach has built an enviable record of accomplishment. Wheat with resistance to the destructive Race 15B is a good illustration. In 1950, this new race of wheat stem rust appeared in the northern Great Plains and destroyed 25 percent of the ripening durum crop. Scientists at Beltsville and in the affected States worked together to develop varieties resistant to Race 15B. By exploiting the Research Center's world collection of wheat germ plasm and performing planting experiments in warmer climates, the cooperating scientists developed resistant varieties in 5 years—a job that would normally require 10 years or more.

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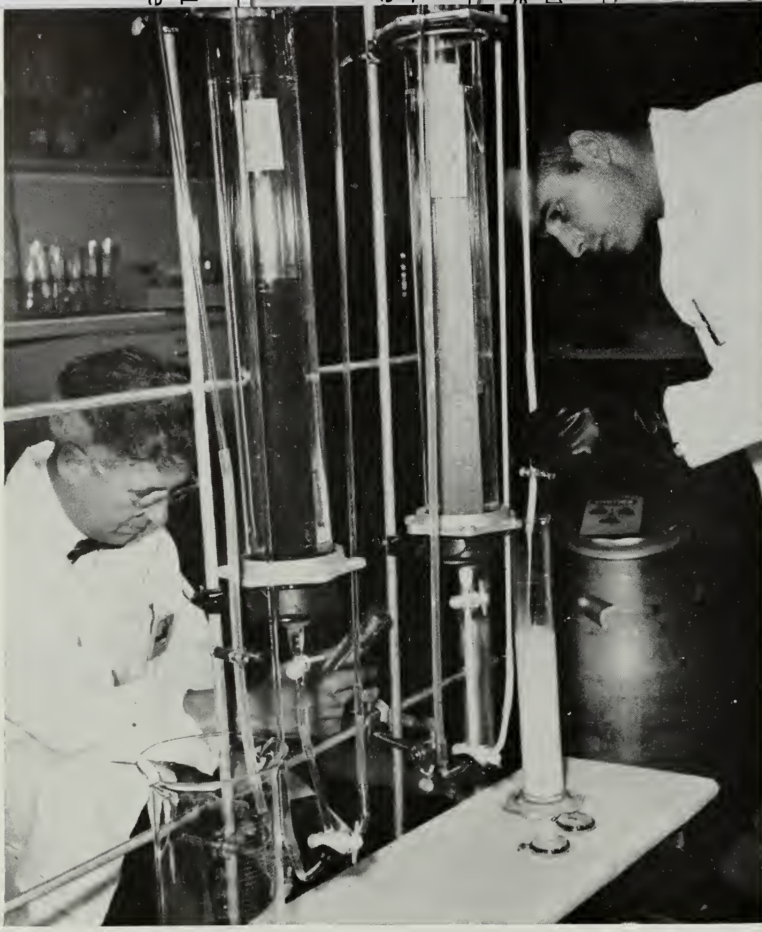

UTILIZATION SCIENTISTS worked out a method of removing radioactive strontium from milk. The method is now being commercially evaluated as a standby measure in the event of a nuclear emergency. It employs ion exchange resins and does not change flavor, nutritive value, or appearance of milk.

As a result of the same type of cooperation, the soybean, which 25 years ago grew only in limited areas, now is one of our major crops. Using imported germ plasm, scientists at Beltsville and other USDA locations worked with State scientists to breed varieties adapted to the different climates of the U.S. The soybean is now an important crop as far north as Minnesota and as far south as Florida.

Beltsville scientists have also made many valuable contributions working independently, usually on problems of broad national interest.

The Beltsville Small White turkey was developed in response to consumer and trade demands for a turkey for small families and small ovens. This compact turkey was bred by crossing several standard domestic breeds with several wild breeds.

Hybrid lambs that gain faster, grow larger, and produce better wool resulted from 8 years of crossbreeding sheep. This work involved breeding nearly 3,000 ewes and weaning 2,500 lambs.

Strain 19 brucellosis vaccine, developed at Beltsville, has been an indispensable tool in the drive to eradicate brucellosis from livestock and undulant fever from man.

Beltsville scientists played a major part in the discovery and development of the weed killer 2,4-D, which started the revolution in chemical weed-control practices 20 years ago. This herbicide kills plants by inhibiting essential plant physiological processes and interfering with plant metabolism. Since the development of 2,4-D, Beltsville research has contributed to the development of other growth-regulating compounds having a wide range of practical uses: thinning tree fruits, stimulating root cuttings, improving fruit set and size, and accelerating or retarding growth of poinsettias, chrysanthemums, and other ornamentals. Additional benefits from using growth regulators include plants that have richer green foliage and that do not wilt as readily as untreated plants.

Aerosol spray used widely

The aerosol bomb was developed at Beltsville to provide servicemen with a means of controlling disease-carrying pests during World War II. The aerosol principle is now used in packaging hundreds of products—from shaving cream to paint.

Beltsville scientists keep up a constant search for new crops valuable to U.S. industry. Crambe is an outstanding find in this search. Crambe seeds are rich in erucic-acid oil, now obtained from imported rape seed and used in rubber manufacture. Chemists foresee many industrial uses for crambe-seed oil, including synthetic fibers, detergents, plastic coatings, high-detergent lubricants, and resin paints. Field trials are being conducted in several States to show where the crop is adapted and which cultural practices are best.

Energy-saving kitchens

To answer needs of homemakers, scientists at Beltsville have designed kitchens to reduce walking, lifting, and reaching. Although these modern, energy-saving kitchens are im-

VISITORS from all parts of the world travel to Beltsville to discuss research projects with ARS scientists or to attend events like this ARS Crops Protection Field Day. Here visitors are inspecting the herbicide evaluation plots.

portant to all families, they are especially valuable to the more than 10 million physically handicapped homemakers in the U.S.

These are just a few of the ways research has been and is being applied to solve immediate problems. To insure a continuing foundation for applied research—at Beltsville and other ARS locations—the proportion of basic research has been raised from about 7 percent to about 35 percent in the last 12 years. This trend is expected to go on until 50 cents of every ARS research dollar goes into the quest for basic knowledge. With such basic understanding, the scientist will be better equipped to solve problems before they become critical.

Resistance to diseases, insects

It will be basic research, for instance, that will explain what makes a plant resistant to diseases and insects. If the source of resistance should turn out to be chemical, a test might be developed that would quickly tell breeders whether a prospective variety will measure up.

Stepped-up research is underway on methods to exploit the weaknesses of insects. Scientists are seeking more knowledge on the types of diseases that attack insects in nature as well as the conditions that cause these diseases to spread through insect populations most widely and destructively. As this information becomes available, it should give clues that will lead scientists to improved weapons against costly insect pests.

Added emphasis is also being given to research on livestock parasites. There is no effective way now to control more than half of the known cattle parasites, which continue to slow down growth, cut production, and cause the animals to use feed inefficiently.

Beltsville scientists are intensifying their efforts to learn more about the basic reactions of weeds and crops to chemical herbicides. They're trying to find out why a weed killer is effec-

Turn Page

BEEF CATTLE researchers are using identical twins to compare the performance and carcass characteristics of bulls and steers—and to determine the effects of continuous versus interrupted growth of beef cattle.

tive on one plant and not on another. If they can find a chemical that stimulates weed seeds to germinate in the soil all at one time, a single application of a pre-emergence herbicide might free the field of weeds before the crop is planted.

The need for more efficient use of water in agriculture is urgent, and Beltsville scientists are part of the USDA-State search for basic knowledge about moisture—how it moves into, through, and out of plants; how it evaporates and moves through the air; and how it reacts with soil and other materials. Out of this cooperative effort may come revolutionary methods of reducing crop needs for water, for collecting and storing rainfall and runoff, and for replenishing soil moisture used by crop plants.

In a search for nonchemical methods of controlling insect pests, Beltsville scientists are finding valuable clues to insect control through basic studies of the insects themselves. One of the most practical approaches is the use of attractants to lure insects to traps, pesticide bait, or compounds that sexually sterilize them. Attractants may be substances in the insects or in plants, or they may be tastes, odors, lights, or even sounds. All of these possibilities will be explored as basic research points the way.

Fats and blood cholesterol

There is a particular need at this time for more precise knowledge of the relationship between fats and blood cholesterol and heart disease. Human nutritionists and livestock geneticists at Beltsville are working on different aspects of this problem. Nutritionists are studying the role of fats in metabolism. If a relationship between animal-fat consumption, cholesterol, and heart attacks is found, livestock geneticists may have to go further than they have already gone in developing low-fat livestock products. Much has been accomplished in breeding lean-type hogs and cattle. It may be possible also to breed cows that produce milk with less fat.

To continue our search for fundamental knowledge in all phases of agricultural science, we must keep the able scientists we have and be able to attract others. To move ahead in basic research, using modern techniques learned in their graduate training, the scientists must have up-to-date laboratories and equipment. These are being provided as rapidly as our resources will permit.

Beltsville is already an international place name. Scientists and statesmen the world over come to Beltsville to learn more about the work and the methods used there. The extensive use of hybrid corn in Italy and Rumania is only one example of how agricultural technology, based partly on research done at Beltsville, has made friends for the United States around the world. In this and many other ways, the Agricultural Research Center at Beltsville is moving toward its goal of nutritional health and abundance for this Nation and the World.☆

THE LOG LODGE, a well-known landmark at the Center, serves hundreds of research workers and visitors daily. ARS employees use it for meals and informal gatherings—coffee breaks, special luncheons, and honor award programs.

ENTOMOLOGISTS use the cockroach as a "guinea bug" for testing experimental insecticides, attractants, and repellants. Here, electrodes are placed in the legs of a roach to study its physiological reactions.

BROAD IN SCOPE

Beltsville research pinpoints national problems

■ Known far and wide as "Beltsville," the Agricultural Research Center is the home office of 4,800 scientists. About a fourth of these scientists live in the vicinity of, and work at Beltsville. The others are stationed at some 315 field laboratories, many of which are cooperative between USDA and colleges or universities.

The research at Beltsville is primarily on broad, national problems. The following examples of current projects indicate the type and scope of Beltsville activities:

LIVESTOCK

Pastures and barns contain herds and flocks of dairy and beef cattle, hogs, sheep, chickens, and turkeys. These farm animals—plus thousands of small laboratory animals such as rats and hamsters—are used to improve breeding lines, nutrition, management, and parasite control.

Of the many livestock research projects now in progress, those on dairy crossbreeding and parasite control best illustrate the kinds of work Beltsville scientists are doing.

A dairy study is seeking to find out if crossbred cows will produce more milk, butterfat, and solids-not-fat than purebred cows. Two- and three-breed crosses of Holstein, Ayrshire, and Brown Swiss cattle are being made. Performance of the crossbred cows resulting from these matings is being measured against the performance of purebreds in the same herd. This study will continue until reliable recommendations can be made.

Parasite control studies are aimed at the elimination of many of the

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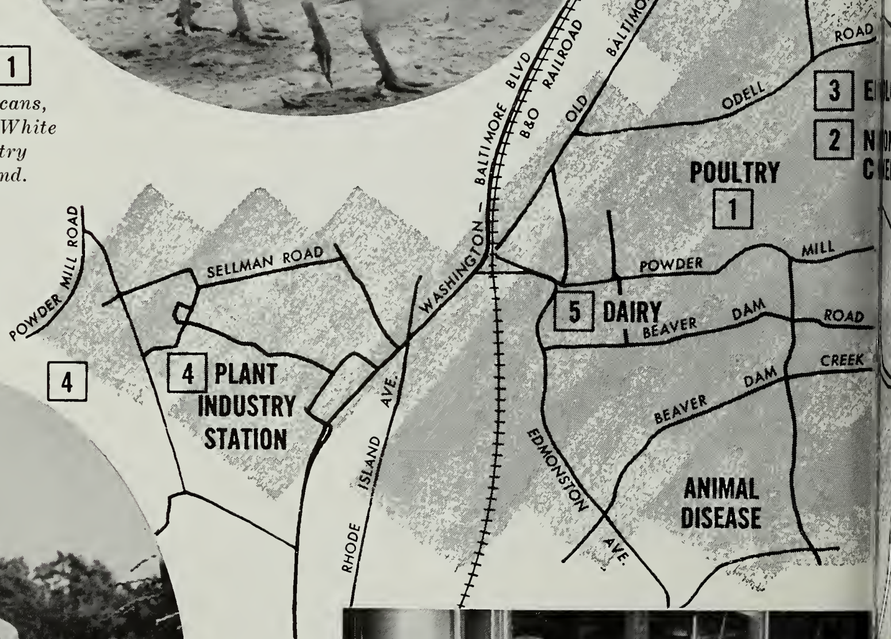
BELTSVILLE: AREA OF ACHI

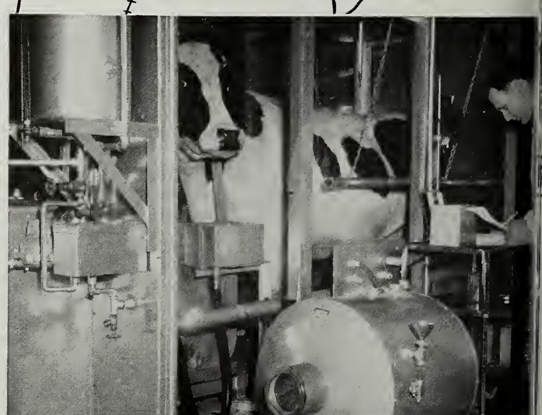
1

BELTSVILLE, to many Americans, stands for the Beltsville Small White Turkey—developed by ARS poultry breeders to meet consumer demand.



PLANT BREEDERS strive continuously for improved crop varieties. About 80 new varieties were released last year in cooperation with States.

4



VEMENT

2

LABORATORY STUDIES have opened the way for improved methods of preparing and preserving foods for home use, school-lunch programs, and institutions.

3

ATTRACTANTS discovered in cockroaches, gypsy moths, and other insects are playing an important role in new approaches to the control of major insect pests.

FEED-USE EFFICIENCY research has helped cut costs by providing information on how cows use different rations in producing milk.

6

MEAT-TYPE HOGS are a well-known product of Beltsville research. Now breeders are investigating hybrid vigor in market hogs by crossing Beltsville inbred lines.

CONTROLLED LIGHTING forced this aphelandra plant to flower in midsummer. It normally blossoms only in October. By controlling light and adding a chemical growth regulator, researchers have produced chrysanthemums, poinsettias, and lilies that are more compact, have darker green foliage, and bloom for seasonal markets.

BROAD IN SCOPE

(*From Page 7*)

worms that invade the digestive tract and sap the strength or life from livestock, causing millions of dollars in annual losses to U.S. farmers.

At Beltsville, parasitologists have developed a procedure for using a clear artificial media for raising and observing parasitic roundworms of livestock outside their animal hosts. The scientists hope to learn what these parasites must get from their hosts to survive, and what is the weakest or most vulnerable stage of development in their life cycles. When these two questions are answered, the scientists will be better able to find ways to control or eradicate these pests.

CROPS

Developing new and improved varieties of plants is one of the most important parts of crops research at Beltsville. Scientists here work on crops grown in many parts of the country. Rice, cotton, sugarcane, castorbean, and wheat can be seen in Beltsville greenhouses along with potatoes, tobacco, corn, alfalfa, soybeans, and other crops.

About 80 new varieties are released to growers, seedsmen, or breeders each year. All are genetically improved to resist pests or diseases, add flavor or nutritional value, or improve growth efficiency.

Under development now, for example, are varieties of rice that will grow when irrigated with cold water, raspberries that will resist a virus mosaic disease, potatoes better suited for commercial processing, tomatoes that resist curly top disease, and apple trees that bear a crop each year.

Much breeding research is aimed at developing basic genetic stocks and is in cooperation with experiment stations in areas where specific crops are normally grown. Work at Beltsville is usually on basic genetic problems, which, when solved, lead to crop improvements of practical value in different parts of the country.

In addition to breeding research, crop scientists at Beltsville also study chemicals for controlling weeds, regulating plant growth, and curing diseased plants. And they conduct a worldwide search for plants with new genetic properties for improving existing crops or promising new plants such as crambe, which has seeds containing an oil of potentially great industrial value. There is a continuous flow of seeds of new plant materials from all parts of the world through Beltsville to experiment stations in the 50 States.

ENGINEERING

Only a few years ago, most of the Nation's tree fruit was picked by hand—one fruit at a time. Engineers at the Center cooperated with engineers in State experiment stations to drastically change harvesting methods. From this research have come machines and methods that completely mechanize harvesting and handling of

certain crops. Even cherries can be harvested, handled, and processed without hand labor.

In recent years, progress in farm mechanization has been phenomenal, but even greater improvements are foreseen. Agricultural engineers at Beltsville are working now to improve the precision of seed and fertilizer placement, an advance that will greatly increasing farming efficiency.

Improved quality of farm products is constantly being sought by Beltsville engineers. A study just getting started is aimed at finding the most effective and economical ways of maintaining flavor and other desirable qualities of milk during handling and storage on the farm.

In a study on improved storage and handling of livestock feeds, radioactivity is being used to determine the density of silage in upright silos. This research should lead to better methods of storing forages and improved silo construction.

SOILS

Soil scientists at the Center are concerned with basic questions about the nature of soil. In laboratories and greenhouses, they are exploring soil in its relationship to plant roots, to natural and artificial water sources, to additives such as fertilizers and herbicides, and to the many organisms that inhabit it.

A series of studies that may prove very important concerns the movement of minor elements and their use by plants. Working with radioactive tracers and X-ray film, soil scientists are finding out how much of each of these minor elements different crop plants need, how these crops use the minute amounts of these elements they take up, and what will be the best way for farmers to supply the right amount and right kind of nutrients to their fields to grow vigorous and nutritious crops. For example, scientists are trying to find pesticides that would break down into useful soil nutrients after they destroy weeds, diseases, or other crop pests.

Another idea being explored is a fertilizer that will gradually release nutrients over a period of several months. If carriers can be found that will disintegrate slowly to release fertilizer as the plant uses it, one fertilization may be enough for each crop planted. It might be possible, for example, to add enough fertilizer to the ground when a young fruit tree is planted to feed that tree through its entire life.

INSECTS

Fighting insects and the diseases they spread has been a major problem since man first started growing his food. Beltsville scientists devote their time to a search for better and safer ways to fight this battle.

Many diseases of plants and animals are spread by insects. Beltsville entomologists are trying to identify the biting flies and ticks that transmit such diseases as anaplasmosis of cattle and piroplasmosis, a newly discovered disease of horses. Once they know the carriers, they can concentrate on developing effective controls.

Chemists at Beltsville are working on laboratory synthesis of natural insect attractants—substances that attract males to females or an insect to a specific crop. Such attractants already have been found and synthesized for the gypsy moth and Mediterranean fruit fly. These and other attractants now being sought for the boll weevil, housefly, and alfalfa weevil will be used more and more in

Turn Page

ENGINEERS determine silage density by measuring the amount of radiation coming through the silage from a radioactive source in the silo.

the future to lure these pests to poisons or disease organisms that are as specific as the attractants.

An example of this type of pest control is the study in progress on boll weevils. A micro-organism was found that kills the pest. A substance that stimulates the insect's appetite was isolated from cotton bolls. The micro-organism is being raised, and the arrestant (feeding stimulant) is being refined in entomology laboratories. Combined, they are being tested in Cotton Belt fields for weevil control.

The team approach is usually followed by Beltsville scientists. A good example of this is at the fly control laboratory. Here, entomologists, animal husbandmen, and agricultural engineers are trying to develop physical methods of controlling the four species of flies most objectional on dairy farms—the house fly, stable fly, horn fly, and face fly. Research will determine the feasibility of using such things as light and other forms of radiant energy, audible and ultrasonic sound, air currents, and geometric patterns for fly control.

PEOPLE

Improving the nutritional well-being of people is the aim of Beltsville scientists who are working to understand and measure nutritional requirements and how best to supply these from our wide variety of foods. In recent research that may lead to better understanding of human nutritional needs, experimental animals suffered ill effects from excessive food intake. Rats that ate excessive amounts and gained at a rapid rate, for example, died at an early age regardless of the composition of the diet. This research, which also covered the relationship or balance of nutrients, is part of long-term investigations on laboratory animals fed numerous experimental diets.

Beltsville research of special interest to homemakers includes studies of housing needs and clothing and textile care and use. Research on the care of clothing, for example, shows that normal home laundry methods cannot be depended on to destroy many disease organisms that may be present on family clothes or linens. Washday products are being evaluated to determine those that will disinfect as well as clean.

UTILIZATION

How to preserve and protect the good qualities of meat and milk are the goals of utilization scientists at Beltsville. Most USDA research on the development of new and better uses for farm products is conducted by four regional divisions. The two groups at Beltsville are field laboratories of the Eastern Utilization Research Division, which is headquartered at Philadelphia.

Meat technologists at Beltsville are seeking ways to better preserve the good flavor and nutritional value of meat and meat products. In their studies of meat proteins, enzymes, and fats, these scientists are learning how to prevent the growth of organisms that cause rancidity and what chemical and physical properties of meat are important in maintaining quality.

Other utilization scientists at Belts-

BACTERIOLOGISTS are studying disinfectants as a means of destroying bacteria in home laundering. Research has shown that a disinfectant is needed, especially in the case of sickness in the family.

ville are working with Atomic Energy Commission and Public Health Service scientists to develop practical processes for removing radioactive contaminants from milk—just in case such a process ever becomes necessary. One process—using ion-exchange resins—is highly effective without changing the flavor, appearance, or nutritive value of milk.

REGULATORY

In addition to research, ARS conducts programs to keep diseases and pests out of the United States, to control or eradicate pests now present, and to insure the wholesomeness of meat and meat products. The groups charged with these responsibilities maintain laboratories at the Center.

A staff of regulatory scientists tests promising plant pest control materials or methods on a field-trial basis before they are used in large-scale control programs. Staff workers also seek to improve the application of pesticides from planes or ground equipment by designing and building devices such as radios for signaling airplane pilots, dust applicators, and granule spreaders.

Laboratory facilities at Beltsville are used by animal disease eradication workers to diagnose and pinpoint infestations of pests and diseases. For example, a nationwide survey of ticks is being conducted from Beltsville to locate all species capable of transmitting diseases to pets, livestock, and man. Early detection and eradication of localized infestations of dangerous pests are much easier and less costly than living with or attempting to eradicate widespread infestations.

The Federal Insecticide, Fungicide, and Rodenticide Act requires that pesticides moving in interstate commerce be properly labeled and registered. Pesticide regulation scientists at the Center collect samples from interstate shipments of commercial pesticides, analyze them chemically, and test them in Beltsville greenhouses, gardens, and orchards to make sure that these products are not faulty, misbranded, or adulterated.

ANIMAL HEALTH scientists are using time-lapse photography to study disease organisms growing and multiplying on cell cultures. They are seeking improved methods of diagnosing animal diseases.

Meat inspection scientists at Beltsville back up field inspectors by conducting laboratory tests on samples of condemned meat and meat products to find what disease or other contaminant caused the condition responsible for the condemnation.

SUPPORT

To do his job effectively, a scientist often needs the help of scientists and specialists in other fields. At Beltsville, this support includes a branch of the National Agricultural Library and a group of biometricians, especially trained in designing experiments that will produce valid results and in implementing high-speed data processing and analysis.

OTHER AGENCIES

ARS is not the only USDA agency that conducts research at the Agricultural Research Center. The Agricultural Marketing Service has laboratories there for the study of fruit spoilage, seed quality, and insects that attack stored products. A recent development by AMS scientists at Beltsville is a hot water treatment that prevents rotting of peaches during shipping and marketing. This treatment is now being tried on commercial peach shipments.

Forest Service scientists at Beltsville do research on insects and diseases that would destroy our woodlands. These scientists are particularly interested in chemical insecticides or biological agents that will control pests but are harmless to man, animals, and wildlife. Forest scientists are also testing newly developed hybrids of poplar, ash, maple, and pine trees for resistance to harmful insects and diseases. Many of these new trees grow several times faster than native trees and could prove to be a practical answer to filling future wood needs of our country.

Soil Conservation Service workers at the Center test newly developed methods and materials for conserving soil and water. A study now in progress is on the propagation of salt grasses and other plant materials that could be used to prevent erosion of ocean-front land by tides and storms.

The Food and Drug Administration, of the Department of Health, Education and Welfare, has scientists at Beltsville doing research on veterinary drugs. New facilities at the Center will be used for research and testing of human foods, drugs, and cosmetics.☆

PIONEERING RESEARCH

Scientists explore beyond the limits of knowledge

In 1957, the U.S. Department of Agriculture established at Beltsville, Md., the first of a special group of research units called pioneering laboratories *to denote the particular kind of research envisioned for the scientists that work in them.*

These scientists are expected to explore beyond the limits of present scientific knowledge, purposefully advancing into the unknown in search of fundamental new facts and principles.

There are now 23 USDA pioneering laboratories. Ten are at the Agricultural Research Center.

This article tells some of the ways scientists in the Beltsville pioneering laboratories fulfill their role.

■ Much of USDA's pioneering research is concerned with one of the most exciting challenges in all science: learning about life and the biological functions of living things.

This challenge appeals to pioneering scientists because there is so much about life and basic biological functions still unexplained. Emphasis on such research in USDA is natural, since knowledge about life processes leads to improvements in crop and livestock production.

One of the most basic functions in plant life—and the first biological function in crop production—is the entry of nutrient elements into plant roots. It also is one of the least understood processes in the cycle of life on our planet.

A highly refined and specialized sort of detective work by pioneering research laboratory scientists at Beltsville has resulted in some important progress at solving the secrets of this process.

The scientists get basic information for their detective work in studies with root systems that have been cut from barley seedlings. They place the roots (as many as 10 root systems per sample) in a solution containing a nutrient element in radioactive form, let the roots take in the element, then measure with an ionization detector the rate of intake. Measurements are

PIONEERING SOIL SCIENTISTS are investigating how nutrient elements enter plant roots. Part of this research involves measuring the rate of intake of radioactive phosphorus by barley roots.

made under a variety of intake conditions; scientists change the intake conditions by such devices as varying the oxygen supply or the pH, or by using an intake inhibitor such as fluoride.

Knowing the *rates* at which a radioactive element enters roots when the intake is affected by the various controls used, the scientists can systematically check out the many possible explanations of *how* the nutrient enters the roots.

Perhaps the most significant development so far in this research has been the discovery of how phosphorus gets through the cell wall of the root. The scientists knew in advance that some mechanism in which energy is generated had to be involved in the entry of phosphorus into the root because energy obviously is required to move the element uphill from a dilute solution in the soil to a concentrated solution in the root. Infinitely patient research with excised barley roots pinpointed the source of energy:

Respiration, the energy-producing action that couples oxygen with life, provides the energy for phosphorous entry into plant roots. Pioneering scientists have proved that no phosphorous gets into the root except that which is coupled with the respiratory chain.

As of now, scientists forsee that this new knowledge will lead to ways of using fertilizer and the natural fertility in the soil more efficiently. Beyond that, one of the possibilities is better knowledge about the movement of salts through the human stomach and intestines; membranes at the surface of plant roots function much as those in the human body.

PIONEERING VIROLOGISTS have developed a virus purification method that employs columns of agar. Using this inexpensive equipment, they separated out tobacco mosaic virus by particle size.

Effect of light on plant growth

The main focus in one pioneering study at Beltsville is on a plant pigment called phytochrome. Its existence was proved at Beltsville, it was named there, and much of what is now known about the pigment was discovered there.

Phytochrome is a protein, but its exact chemical nature is not yet clear. It is known that the pigment is vitally involved in a photochemical reaction that governs plant growth and development.

With knowledge gained in studies of phytochrome, pioneering scientists can now explain why chrysanthemums flower when nights become long:

Phytochrome exists in two forms. In one form—the form that is predominant when the plant receives light—phytochrome inhibits flowering. When darkness comes, the pigment begins a gradual change to a form that does not inhibit flowering. If dark periods are short, the plant does not flower because sufficient pigment remains in the flowering-inhibiting form to prevent flowering. If dark periods are long, however, the flowering-inhibiting form of the pigment falls below the minimum required for flowering inhibition, so the plant flowers.

Chrysanthemum is only one of many plants being used in the phytochrome studies.

Why all this concentration by some of the world's foremost scientists on a single reversible photochemical reaction and the pigment that triggers it? Profound implications are involved in the answer: In addition to governing flowering, the photochemical reaction governs other developmental phenomena such as seed germination, pigmentation, stem elongation, and leaf expansion.

When scientists fully understand the photochemical reaction, they almost certainly will have accomplished more than advancing the frontier of knowledge about plant life. Quite probably, they will have developed knowledge that will lead to the ability to control or regulate plant growth (and crop production) in ways that now challenge the imagination.

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Highly purified virus

Many virological studies require virus and other components from infected and healthy tissue in highly purified form. Obtaining such material has often involved expensive, time-consuming, and elaborate procedures. So when Beltsville pioneering scientists recently announced a simple procedure that requires little time, it was enthusiastically hailed.

The principal equipment in the new procedure is a glass tube containing agar gel that has been chopped and washed through sieves to obtain agar chips of the desired size.

When a virus-containing extract is placed on the top of the agar-gel column, particles in the extract are separated according to size—particles of different size move through the column at different rates.

Essentially, then, the procedure consists of layering a virus-containing extract in the top of an agar-gel column, and collecting fractions at the bottom.

One of the most recent accomplishments with the agar-gel procedure was the complete fractioning (separation by particle size) of tobacco mosaic virus, a rod-shaped virus. Preparations from other techniques yield tobacco mosaic virus rods of various lengths. Separation with agar gel enabled the pioneering scientists to show that infectivity is associated with rods of a certain length.

In one respect, the agar-gel separation procedure is typical of many of the developments of pioneering research: It is useful for other jobs as well as the one for which it was originally developed. It can be used to separate proteins, enzymes, and small cell components and accelerate the study of several basic life processes.

An insect pathogen

The bacterium *Bacillus thuringiensis* is an effective insect pathogen; it kills at least 110 species of Lepidoptera (an insect order that includes gypsy moth and corn borer) and 4 species of Diptera (an order that includes house flies and fruit flies).

Cultures of *B. thuringiensis* have been prepared and sold by commercial firms and successfully used in both experimental and practical applications. Because this bacterium kills insects but is harmless to man, animals, and plants, it has been the subject of considerable research by scientists at Beltsville and elsewhere.

They have learned, for example, that *B. thuringiensis* produces at least five different toxic materials. One of the most toxic of these five substances is a diamond-shaped crystal formed when the bacteria sporulate. A few minutes after a susceptible insect consumes this crystal toxin, feeding is stopped by intestinal paralysis—and crop damage ceases. Following paralysis, the gut wall degenerates; in some insects it becomes permeable and the gut contents leak out.

Important questions to be answered: Exactly how is the crystal toxin formed? What is its chemical structure? Can it be synthesized? What is the chemical structure of the gut substance attacked by this toxin? How is this substance attacked—is the crystal the precursor of an enzyme, which under suitable conditions in the insect gut attacks something in the sensitive site?

Answers to questions such as these are somewhere beyond the limits of present knowledge, but pioneering scientists at Beltsville have made enough progress in their research to justify confidence that answers will be found. For example, procedures have been developed for isolating all of the five toxins and studying their action.

When scientists have complete information on how *B. thuringiensis* kills susceptible insects, they not only will have answers to some fundamental questions about biological processes but may well have entirely new approaches to insect control.☆

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